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Nuisance Alarms in Aircraft Cargo Areas and Critical Telecommunications Systems: Proceedings of The Third NIST Fire Detector Workshop

William L. Grosshandler
Editor

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EXECUTIVE SUMMARY

The need for faster and more intelligent decision making regarding the presence or absence of a fire threat has become acute in the commercial aircraft and telecommunications industries, both of which have been particularly hard-hit by the cessation of halon production. The drive toward earlier detection has as a consequence the possibility of increased rate of nuisance alarms; however, there are no accepted standards against which a fire detection system can be operated to assess its immunity to false alarm. A workshop was held at NIST with the main objective to identify physical sources of nuisance alarms that may plague current and emerging fire detection technologies for telecommunications applications and for aircraft cargo areas, to reach consensus on what test methods are appropriate to evaluate a detection system's immunity to false alarm in the presence of physical nuisance sources, and to recommend actions to develop and/or implement these new test methods. The workshop consisted of a number of invited background talks from representatives of the aircraft and telecommunications industries and government agencies. The current state of detector evaluation methodologies was reviewed, along with what has been documented in the open literature regarding the number and sources of nuisance/false alarms in these two applications. Groups were formed from among the participants to discuss relevant issues, followed by open deliberations in an attempt to arrive at a consensus. Among the topics were defining realistic fire threats and simulating them; documenting existing environments; simulating environments that lead to false alarms; determining requirements of the industry with regard to the tolerable rate of nuisance alarms; and examining current operating practices as a means to identify opportunities to reduce false alarms. This report summarizes the discussions and presents the major findings for each application.

Key recommendations for both the airlines and telecommunications industries include the following:

- Develop consensus on what constitutes "acceptable" performance for new classes of detection systems, including the fire threats to be detected as specified by fuels, geometry, rates of heat release, smoke generated, and times to detection.

- Compile background data from currently installed fire detection systems to account for the number of fire incidents, the number and major sources of nuisance alarms and the associated actions and costs, and to establish the range of conditions normally encountered in the non-fire state.

- Expand capabilities to simulate common environmental nuisance sources including relative humidity, condensation, dust, combustion engine exhaust gases, and soldering operations, and develop protocols to evaluate detection systems exposed to these environments.

- Investigate methods for evaluating and certifying proprietary software to ascertain its ability to discriminate a fire from a non-fire state in the presence of nuisance background sources.

- Develop safe, convenient, and scientifically sound techniques to certify detection systems as installed in the field.

(Note that the authorship of this report is diffuse, but the major contributors to each section are noted. The editor has heavily paraphrased the statements of the contributors, but also has taken the liberty to fill in or expand to improve continuity or understanding for the reader.)

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NUISANCE ALARMS IN AIRCRAFT CARGO AREAS AND CRITICAL TELECOMMUNICATION SYSTEMS

INTRODUCTION

The Building and Fire Research Laboratory at NIST held the third in a series of workshops on the topic of fire detection in December, 1997 in Gaithersburg, Maryland. The previous workshop, held in February of 1995, had a number of objectives: to identify the needs of users and specifiers of fire detection systems which were not being met; to highlight future needs which could result from new developments in the construction, transportation, and manufacturing sectors, or from regulatory changes; to identify generic technological barriers which were limiting the fire protection industry from fully meeting the users' needs; and to develop a research agenda and recommend priorities to enable U.S. industry to overcome these technological barriers. The proceedings from that workshop are available in a NIST Internal Report[1].

Research has been ongoing and new detection systems have come onto the market which address some of the concerns brought out in 1995. However, the need for faster and more intelligent decision making regarding the presence or absence of a fire threat has become more acute in a number of critical applications. Fire detection in commercial aircraft and in the telecommunications industry are two such applications, and these have been particularly hard-hit by the cessation of halon production.

Combination multi-sensor detectors, miniature solid-state gas sensors, fiber optics, multiple species infrared sensing, trained neural networks, machine vision, and sophisticated signal processing methods were mentioned at the last workshop, and most are still actively being pursued in the laboratory. The performance of these and other new technologies need to be evaluated against a realistic fire scenario, for which a number of generally accepted standards exist. As important as the detection system's ability to sense an actual fire is its ability to not be fooled by a non-fire stimulus. Although limited field data exist on the causes of false alarms in certain applications, and although manufacturers, users and researchers each have their own ideas about what might trigger a nuisance alarm, there are no accepted standards against which a fire detection system can be operated to assess its immunity to false alarm. The third NIST workshop examined this issue. Its main objective was to identify physical sources of nuisance alarms that may plague current and emerging fire detection technologies for telecommunications applications and for aircraft cargo areas, to reach consensus on what test methods are appropriate to evaluate a detection system's immunity to false alarm in the presence of physical nuisance sources, and to recommend actions to develop and/or implement these new test methods.

The following questions were posed to the participants:

1. What fire detection systems are currently being used in the telecommunications and commercial aircraft industries?

2. What are the industries' definitions of a "false" or "nuisance" alarm, and what are the primary sources?

3. Are new, low-false-alarm technologies emerging that are practical for use in telecommunication facilities and aboard aircraft?

4. What physical environmental conditions (e.g., temperature, pressure, moisture, particulate levels, air flows, gas concentrations) are most likely to be confused with the early stages of a fire on board an airplane or in a telecommunications facility?

5. What activities or events are most likely to generate these conditions (e.g., maintenance, cleaning, normal heating and cooling, rain, human presence, operation of adjacent equipment)?

6. Can a consensus be reached on what new metrics need to be developed, and on what the roles are for the different parties in developing them (manufacturers, users, UL, FM, NIST, NFPA, FAA, NASA)?

The workshop consisted of a number of invited background talks from representatives of the aircraft and telecommunications industries and government agencies. (The agenda with names of speakers is listed in Appendix B. The list of attendees with their affiliations is attached as Appendix D.) The current state of detector evaluation methodologies was reviewed, along with what has been documented in the open literature regarding the number and sources of nuisance/false alarms in these two applications. Groups were formed from among the participants, as listed in Appendix C, that attempted to answer questions 4, 5 and 6 as they applied to either the aircraft or the telecommunications industry. On the second day, a representative from each group summarized the discussion from the breakout session and proposed answers to the rest of the workshop participants. Open deliberations then followed in an attempt to arrive at a consensus.

This report describes the activities of the workshop and summarizes the key findings. Background on fire detection problems in critical telecommunications facilities and in aircraft cargo areas are presented in the following sections. Recommendations for future actions are included next. Current methods for evaluating general fire detection systems exposed to nuisance and actual fire sources are reviewed in Appendix A.

FIRE DETECTION FOR CRITICAL TELECOMMUNICATIONS EQUIPMENT

A telecommunications industry perspective of fire detection was given by Ron Marts of Bellcore. Miles Hanley of Bell Atlantic presented his company's fire detection strategy and its relation to the reduction of false alarms. Jeffrey Betz described the fire safety practices of AT&T. John Parssinen of Underwriters Laboratories presented an overview of different fire detectors and described UL's role in certifying detection systems for industrial applications. The discussion sessions were led by Richard Bukowski and Emil Braun, both of NIST. This section of the report is a compilation of their comments and the discussions that ensued.

Background

A fire in a critical telecommunications facility poses a number of unique problems that the earliest possible detection could help alleviate. First, the lost service associated with the down time from a fire is normally much more significant than the loss due to property damage. Because of this, taking equipment off line to remove the electrical power is to be avoided if possible, but if necessary it must be accomplished in an orderly fashion by trained employees, which may be inconsistent with the needs or desires of the fire fighters. In many situations, removal of power is sufficient to extinguish the fire since much of the material used in telephone equipment does not readily support a flame. Conversely, for high electrical current devices, the fire may never be fully extinguished even by

applying a suppressant unless the power is removed (or the fuel is totally consumed). Water can create a personnel hazard when applied to electrically powered equipment and short out adjacent devices. Halons generally pose no problem if they come in contact with electrical equipment, but alternatives such as fluorocarbons and hydrofluorocarbons tend to form larger concentrations of acid gases when applied to a fire, increasing the possibility of collateral damage caused by the deposition of acidic soot on remotely located equipment.

Thus, early detection of a fire threat is paramount to the telecommunications industry to permit the widest choice of responses to minimize possible losses. However, if not done intelligently, the rush to earlier detection could lead to an increase in nuisance alarms to unacceptable levels.

Ron Marts: The following statistics were cited to put the size of the regional Bell operating companies (RBOCs) into perspective: there are 140 000 000 access lines, 13 000 switches in 7500 cities and towns being served, 10 400 central offices, and 14 000 000 m^2 (150 000 000 ft^2, or equivalent to 150 large shopping malls) of floor space in need of fire protection. The RBOCs have an embedded base of about 1 000 000 smoke detectors, 10 000 control panels, and are served by 8500 fire departments. In the last 25 years, there have been only six major fire incidents, with no deaths due to fire in the 120 year history of the Bell system. Nuisance alarms occur, but have not been epidemic.

The nature of the spaces to be protected has changed with advances in communications technologies. In the "old days", switches were analog, 3.36 m (11 ft) high placed in rows with tight aisles in rooms with 4.9 m (16 ft) ceilings. The ventilating system had slow moving air and the cable materials were combustible, leading to hot flaming fires when they did occur. Many people were available in or adjacent to the critical switching rooms to detect a fire. These switches contained relatively unsophisticated redundancies but were not highly susceptible to airborne contamination. Early strategies for fire protection were driven by AT&T/Western Electric's desire for uniformity, i.e., the one-size-fits-all approach. Facilities were equipped with standpipes and hoses, and hand-held fire extinguishers contained CO_2 or water as dictated by code. Smoke detection was through high voltage ionization sensors, with one detector in each 6.1 m by 6.1 m (20 ft by 20 ft) building bay. The fire signal was handled as a trouble alarm, and the employees were trained in how to react to the alarm.

In today's world, the switches are digital with many sophisticated redundancies. The frame heights have been reduced to 2.1 m (7 ft), but the ceiling heights remain unchanged. The more compact nature of the digital switches leads to their placement in clusters with tight aisles and frequently in large open spaces. The combustible cable materials have been replaced with much more flame resistant wiring, and the HVAC systems use fast moving air. An ignition event in this type of architecture might result in a smoldering fire with a low rate of heat release and stratifying smoke layer. Few people are present, and the equipment is highly susceptible to airborne contamination. While the central office (CO) is still the major hub of land line service, the divergence of network requirements has created the need for satellite facilities such as remote huts, repeaters, underground controlled environmental vaults (CEV) and on-premises switching (installing telephone switches on customers' premises, as opposed to the telephone company's buildings). The boom in cellular telephone use has created the need for tens of thousands of cell sites (the location of the antennas) where the signals are relayed to ground-based mini COs. The surge of competition in the industry has created hundreds of competitive local exchange carriers (CLEC) who are allowed to install their equipment in incumbent local exchange carrier's (ILEC) facilities.

Current fire protection strategies are driven by many forces, including code requirements, Bellcore and intra-company practices, available technologies, and risk management and business needs. Standpipes still exist in all COs, but many companies have chosen to remove hose cabinets. Fire extinguishers are installed according to building codes, NFPA 10, and Bellcore recommendations. Companies are shifting to very early warning detection systems, either low voltage photoelectric spot

detection or aspirating systems, or a combination of both. These systems offer higher levels of intelligence and can be supervised remotely. Fire alarms are routed to the company's switching control center (SCC), building operations control center (BOCC), and to the local fire department. It is the fire department, not the employee, that is trained to respond to a full alarm. Many companies have fire fighter training programs, so that the local fire departments can familiarize themselves with the CO.

Bellcore's position is that there is no such thing as a "false" alarm since every alarm tells you something. A wanted alarm can be thought of as a "good" alarm bringing bad news, and conversely, an unwanted alarm is a "bad" alarm bringing good news. The unwanted alarm could signify a non-fire problem with the detection system or its environment, which should be corrected, or it could be a response to a non-threatening physical source and construed as a nuisance. (The fire department views nuisance alarms as false alarms.) Nuisance alarms can be put into five categories:

- contractors' work, such as welding or other hot processing, physically damaging the equipment, or improperly disconnecting equipment;
- maintenance, or lack thereof;
- supervisory problems with equipment;
- contamination of the air or the interior of the detection system by smoke, dust, humidity or paint fumes; and
- lightning.

In summary, Marts stressed that modern telecommunications equipment is compact, and frequently in large open areas with a high level of cooling through fast moving air. The telephone switches present a low fuel load categorized as a class C light hazard, producing a slow burning smoldering fire but with a high susceptibility to contamination from smoke. Highly maintained, very early warning, intelligent detection is used with multiple levels of alarm. Fast response and entry by a properly trained fire department is the main defense, as opposed to fixed, automatic suppression systems. The history of nuisance alarms varies among companies, but none report them as being epidemic, typically less than one a day for an individual company. Bellcore continues to explore new technologies in fire protection for its clients and to create uniform and consistent recommendations for them. Bellcore is a vendor-neutral fire protection consultant and participates heavily in the code change activities of the model codes and the IBC, in various fire protection symposia, and serves as an active member of the new NFPA Telecommunications Committee.

Miles Hanley: The fire detection strategy for Bell Atlantic and its relation to the reduction of false alarms was presented. The systems which were in place prior to the new strategy were high voltage and hard wired, consisting mainly of ionization-style heads. They also had installed early versions of low voltage non-addressable heads. A decision to upgrade was made based upon the findings of the Network Reliability Counsel, the desire for incipient (low energy) fire detection, the age and high maintenance costs of the previously installed systems, and the desire to reduce the number of false alarms.

The major causes of false/nuisance alarms at Bell Atlantic were given as the following: dirty heads, soldering in the main frame area, cigarette smoking, high airflow, construction dust, and incorrect detector application. Statistics were cited which indicated that replacing the existing systems with an addressable system would cut in half the dollars spent on alarm call outs; and by going to air sampling with addressable heads, Bell Atlantic could reduce costs by another factor of two. A system-wide upgrade was projected to save the company about $125 000 a year due to the reduced number of nuisance alarms.

Non-equipment areas are now protected with addressable, analog spot detectors. This includes

hallways, lunch/break rooms, and rest areas. The central office switches, including toll rooms, main frames, and power rooms, rely upon air sampling using a piped network with laser detection. These systems have an adjustable sensitivity level, a time delay, built-in air filter cartridges, and an ability to set the alarm threshold above the prevalent ambient condition. In addition, they are equipped with drift compensation, a maintenance alert, addressable detectors and sensitivity adjustment, alarm verification and pre-alarm capability, with alarm decision algorithms programmed into the software.

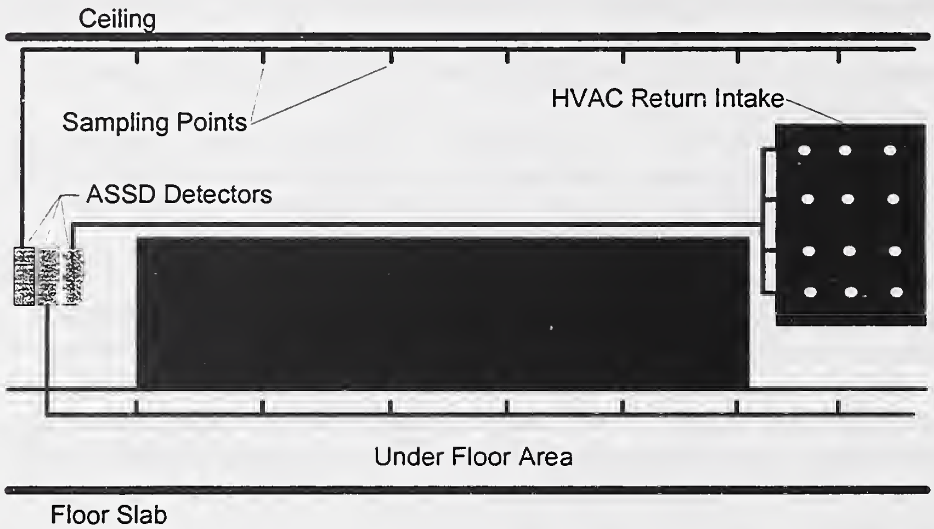
Jeffrey Betz: The activities of the engineering environment, health and safety processes at AT&T were explained as they applied to fire detection and safety. ANSI, ASTM, and NFPA (70 and 72) standards provide guidance in the design, installation, operation, testing and maintenance of buildings, systems, processes and equipment. AT&T Practices and AT&T Letters present the company's prescribed level of acceptability or approved model used as a basis of comparison to the standards. Fire prevention minimizes the likelihood of fire, but if it occurs, fire spread is restricted by the strict enforcement of standards/practices/codes, by limiting the potential for ignition sources to be consistent with designed occupancy, by good housekeeping and storage practices, and by proper management of access and egress. Fire control based upon enforced standards/practices/codes minimizes a fire incident or smoke condition spreading beyond the area of origin by careful planning of the site and space layout, by compartmentalization, by smoke management, by proper selection of structural and fire protection materials, and by assured fire service access.

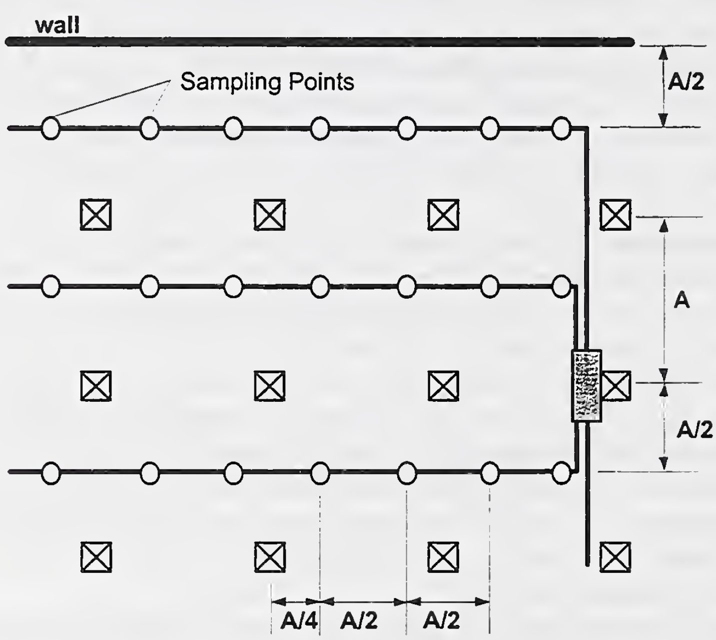
Fire detection is designed to detect a fire condition as early as possible, so that actions can be taken to prevent smoke generation and open flames, to evacuate occupants, and to minimize damage to property and the network. Activation of the fire alarm system is through any of the following actions: manual pull station; positive response of an individual detector; or by a fixed system. All standard designs of fire detectors (smoke, heat, and flame) are encountered in AT&T facilities, including sprinkler heads. Air sampling smoke detection systems (ASSDS) are used specifically to protect priority equipment spaces, but early warning detection is the general philosophy for all telecommunication facilities. Figure 1 shows a sectional and plan view of a typical system. In it, air is continuously drawn from a protected area through a network of piping with sampling holes at specified intervals.

AT&T Engineering and Operation Practices documents require that the selection of a smoke detection system be based upon the type of fire most likely to occur in the space being considered, the potential for damage from a fire in the area, the potential for smoke damage, and the types of materials that may burn in a fire. Changes in the use of a room or space (i.e., from offices to equipment) will change the type of detection required because the materials present will change. All leased or owned buildings, structures, huts, and CEVs containing network communications equipment shall be provided throughout every area/room with an automatic detection system. This requirement applies to all AT&T areas with three-dimensional conveyances (3DC) and condo agreement buildings. Photoelectric type spot detectors are appropriate for use in non-priority areas such as storerooms, janitor closets, toilet rooms, cafeterias and break rooms, administrative offices, hallways, and mechanical equipment rooms. Ionization detectors are specifically precluded from use in these areas.

Multi-sensor type spot detectors integrate into one unit a photoelectric, ionization, and/or heat sensor. The sensor outputs are linked through an integral microprocessor which interprets the combined signals through an intelligent algorithm to produce a signal that is more sensitive to a variety of fires. Ultraviolet flame detectors are used in the presence of combustible liquids, while UV/IR combination sensors are designed to reduce the tendency of a flame detector to false alarm in the presence of arc welding, lightning and sunlight. Heat detectors are acceptable for telecommunication facilities that are not compatible with the use of smoke or flame detection. All heat detectors are of the

Air Sampling - Very Early Smoke Detection Apparatus (VESDA)





A = Column Spacing (center - to - center) - Typically 20 ft.

AT&T

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Figure 1. Layout of a very early smoke detection system for a telecommunications facility.

rate-compensated, fixed-temperature type, and are individually addressable through an interface panel. Spaces which are commonly protected with heat detectors are generator rooms, penthouses, garages/loading docks, and separated unheated storage. Fusible-link heat detector/sprinkler heads are used in non-telecommunications areas.

Photoelectric spot detectors are spaced to cover 37 m^2 (400 ft^2) each in administrative or common areas and in cable vaults. Individual air sampling ports tied to photoelectric sensors are spaced to cover 18.5 m^2 (200 ft^2) when used in cable vaults, in priority telecommunication spaces, and in data center/computer rooms.

Experience has demonstrated that when heating, ventilation and air conditioning (HVAC) systems are operating, the first detector to recognize a fire will be sampling the return intakes from affected space. If the HVAC systems are not functioning, then the ceiling/raised floor detection system will respond most quickly. Not less than two separate detector control units are required in every priority telecommunications equipment room. One detector covers the HVAC return air intake, and a second detector covers the ceiling of the room.

Fire detection systems are functionally tested (at prescribed intervals) to ensure that each and every device, appliance and operational mode is performing as designed. This includes all smoke, heat and flame detectors and associated devices or appliances, and encompasses interactions, interlocks and special features. False alarms in these systems can be attributed to intentional activation, improper installation, or improper maintenance activities. The term nuisance alarm is applied to conditions resulting from an improper installation or misapplication of a detection device, a changing environmental condition, improper maintenance activities, or “friendly” fire/smoke.

John Parssinen: Different types of fire sensors certified by Underwriters Laboratories for use in telecommunications and other commercial applications were described. The performance of smoke detectors are evaluated in reduced and full-scale chambers using standards UL 217[2] and UL 268[3]. UL 521[4] applies to heat detectors for fire protective signaling systems intended to be installed in ordinary indoor and outdoor locations. UL 539[5] applies to heat activated, mechanically or gas operated heat detectors intended for indoor installation. UL 2034[6] covers electrically operated devices designed to protect ordinary locations of family living units, including recreational vehicles and mobile homes, from excessive levels of CO produced in combustion engine exhausts, fireplaces, and abnormal operation of fuel-fired appliances. Carbon monoxide produced in an unwanted fire is not an excluded source, but fire detection is not specifically mentioned as an intended use.

Smoke detectors are listed as being either ionization or photoelectric, with the photoelectric being further categorized as point-type or projected-beam-type. Combinations of these types are becoming more common, with heat detection sometimes also employed. Air sampling can be used in combination with any of these smoke detector designs. Heat detectors can have a fixed temperature set-point as measured at a point or along a line. Rate-of-rise and rate-compensated heat detectors are designed to improve the sensitivity of the system and to reduce the possibility of alarming due to extremes of environmental temperature. Flame detectors certified by UL sense the ultraviolet, infrared, or combinations of these portions of the spectrum. New technology sensors are being developed that sense other fire signatures such as CO and CO_2, and microprocessor based systems are available that allow more flexibility in alarm determination.

Discussion

The discussion sessions were focused on answering the following questions as they apply to critical telecommunications areas: (i) What conditions produced by a nascent fire can be sensed to warn of a threatening situation? (ii) In what time-frame must a response strategy be formulated, and

what are the consequences of a false-positive? (iii) What physical environments or activities are likely to lead to a false-positive? (iv) What test methods are required to evaluate the immunity of fire detection systems to false-positives? (v) What are the action-items for the group, and who should take responsibility for each?

The primary fire signatures in modern telecommunication switch rooms are produced by low energy, smoldering fires. The sources could be cabling, PVC, or plastic housings. Smoke stratifies below the ceiling and is generated in abundance. Current detection strategies involve layered protection; i.e., sampling from different heights in the room to overcome problems due to smoke layer stratification. Temperature increases are low in these types of fires, but near the reaction zone they can be hundreds of degrees above the highest measured ambient. HCl is produced by the decomposition of PVC cables, but current smoke detector technologies can match the sensitivity of HCl detectors without the disadvantages (high maintenance, non-response to fuels not containing chlorinated species). CO and CO_2 are produced from all fires of carbon-based materials and could be indicative of a growing threat, but the reliability of current gas sensing technologies have yet to be proven.

Other distinct fire scenarios could result from cabling under raised floors similar to configurations in mainframe computer rooms, or from hydrogen production in battery rooms. The materials used in these areas (e.g., battery cases, fuse housings, power cables) may differ from the switch room. Selective gas sensors might give earlier detection, but records of fires in raised floor areas and battery rooms indicate that losses are very low in these scenarios, which may suggest that these environments are sufficiently protected with existing technologies.

The amount of time available between the detection of a fire and the onset of a mitigation strategy is dictated conventionally by the maximum size (expressed in terms of heat release rate, or HRR) of fire that can be tolerated and the growth rate. Maximum tolerable sizes are generally less than 100 kW, with some deeming 25 kW to be an upper limit. Detection should occur prior to an HRR of 1 kW (0.1 kW is suggested by some for critical equipment particularly susceptible to smoke damage). For these situations, the rate of production of particulate matter may be a preferable gauge of the fire severity rather than HRR since the rate of heat generation over and above the heat dissipation of the electrical power may be minimal.

The actual time available between the onset and detection of the fire is controlled mostly by the practical response time for the given operation. For a central office with even minimal staffing, an employee can investigate an alarm signal in less than a minute, at which point the fire can be confirmed and a decision made to isolate and depower the affected piece of equipment, to activate a suppression system (few telecommunications operators utilize automatic release of agent), to power-down more extensively (considered a last resort action), and/or to notify the fire department. On the other hand, cell sites are often remote, requiring times greater than an hour for an employee or the fire department to investigate. If it is a real fire and the site is not equipped with an automatic suppression system, the equipment will be written off. The fire alarm in that situation acts as a signal to the maintenance crew to install a new facility.

Fire alarms divert people to investigate the source, cause the telecommunications company personnel to evacuate a central office, and may result in the dispatch of the fire department. If the alarm is the result of a false-positive, then as a minimum there is a dollar penalty associated with the lost productivity of the employees, plus any cost to the fire department if they respond. If the facility (such as a remote cell site) is equipped with an automatic suppression system, a false-positive can lead to the inadvertent release of agent. Automatic power shutdowns are never employed since maintaining a dial tone is paramount; hence, a false-positive will not lead to loss of service. As a rule, a certain level of nuisance alarms are accepted by the industry because they indicate that the fire detection system is operating and responding to something foreign in the environment. A serious problem occurs only when the number of nuisance alarms exceeds an (unknown) desensitization limit, and employee

confidence in the system is eroded.

Nuisance alarms can be traced to a number of sources. Internal to the facilities, the primary causes are poor maintenance of the detector heads, poor housekeeping procedures, particulate formed during routine soldering operations or from a defective light ballast, and excessive moisture or dust. External to the equipment room, emissions from traffic, an idling truck, or road work can be inadvertently entrained through the ventilation system. Adjacent occupancies (e.g., employee lounges, kitchens, garages) can also contribute contaminants through leakage paths in the HVAC system.

Current test methods used by UL to certify that a smoke detector will respond to a fire appear adequate. Methods for qualifying systems in the field are not, and there is no written industry standard for this process. Most installers burn a short length of wire in the room after installation to make certain that the system will respond. This technique is thought to be viable and convenient; however, it is a highly transient event which does not represent the more serious threat of a deep-seated, slowly propagating smoldering fire. In addition, there is a reluctance by the facility owner to expose the equipment to extraneous particulates of any type. Independent methods for testing the performance of fire detection system decision algorithms are non-existent but would give the users more confidence in the systems. New test methods are likely to be needed to confirm a systems' response to non-fire signatures, once a consensus of the critical non-fire states is reached.

AIRCRAFT CARGO AREA FIRE DETECTION

Overviews of fire detection in aircraft cargo areas were presented by David Blake of the Federal Aviation Administration, John O'Sullivan of British Airways, Scott Hammann of Boeing Company, and Matt Kolleck of Booz-Allen & Hamilton. The breakout discussion sessions were headed by Thomas Cleary of NIST and David Blake of the FAA. The following sections are a synthesis of their comments.

Background

Cargo areas of commercial aircraft are categorized according to their size and accessibility as described in the *Code of Federal Regulations* (CFR).[7] Class A and B cargo areas are accessible in flight, so that a fire can be suppressed by the actions of a crew member with a hand-held extinguisher. A class C cargo area is inaccessible in flight. Remote fire detection and suppression capabilities are required for class C spaces, as well as fire resistant wall panels. If an inaccessible (in flight) cargo volume and ventilation rate are limited in magnitude (leakage rate in ft^3/hr plus volume in ft^3 is less than 2000), the space is specified as class D. In the past, class D cargo areas were exempt from requirements for automatic fire detection and suppression as long as the space was totally enclosed and the cargo liner materials met stringent fire resistance requirements. On freighters, cargo spaces specified as class E are required to be equipped with fire detectors and independent ventilation control, but not fixed fire suppression systems. The FAA recently issued a Notice of Proposed Rulemaking[8] that requires fire detectors and suppression systems for all inaccessible cargo compartments, effectively converting class D cargo areas on passenger aircraft to class C. For freighters, the option exists to convert class D spaces to either class C or class E. If adopted, the rule would affect approximately 3000 aircraft that fly in the U.S. and increase the total number of spaces monitored by fire detection systems by about a factor of three.

The detectors most commonly used in class C cargo areas sense the presence of airborne particulates and aerosols. There are three basic types: radioactive ionization, photoelectric light scattering, and photoelectric light attenuation. These are sometimes supplemented by a thermal sensor.

Several detectors can be mounted on the cargo compartment ceiling where they measure the local smoke concentration, or a dual detector can be mounted remotely with an aspirated gas sampling system used to pull material into the detectors from multiple locations. When the smoke and/or temperature exceed a threshold level, an alarm is triggered in the cockpit and the crew responds according to established procedures written in the *Aircraft Flight Manual*.[9]

Cargo compartment fire detection instruments are described in TSO C1c.[10] Smoke detectors are required to alarm when the light transmission is reduced between 4 % and 16 % over a 0.305 m (1 ft) distance. (This is a much larger obscuration level than required by UL 268[2], which states that smoke detectors must alarm between 0.5 % and 4 % for gray smoke, and between 0.5 % and 10 % for black smoke.) The detectors must sense the presence of fire in the cargo compartment within one minute of ignition, according to FAR[7] 25.858. The system is evaluated as installed in the aircraft to be certified by simulating a fire with, for example, theatrical smoke. All fire detectors must withstand environmental temperatures from -30 °C to 50 °C (-22 °F to 122 °F), absolute pressures from 18.6 kPa to 104 kPa (simulating elevations from below sea level to 12 160 m (40 000 ft)), a relative humidity between 0 and 95 %, and vibrations in excess of what would normally be expected on an airplane. Thermal detectors, if present, are set typically to alarm at 88 °C (190 °F) or less.

Class C cargo areas are inaccessible in flight, so that in the event of a detector alarm the usual crew procedure is to discharge fire suppression agent. With halon 1301, the amount needed to keep the fire under control is small (less than 5 % by volume), and the corrosivity and toxicity levels are low enough that an unneeded discharge causes little collateral damage to the aircraft or its contents. The U.S. Environmental Protection Agency has indicated[11] that it will allow halon 1301 to be installed in new systems designed for protecting class D cargo areas, but international pressure is extremely high to phase out all uses of the chemical because of its high potential for depleting stratospheric ozone. None of the available alternatives to halon 1301 perform as well, and in the event of an inadvertent discharge, collateral damage could be significant. Physical damage to cargo, injury or death to animals, and difficulty in cleaning up are the main concerns. Injury can be caused by the high momentum and low temperature of the discharging agent jet, by asphyxiation, or by toxic reaction to the chemical. Toxic reaction due to cardiac sensitization levels below those which lead to asphyxiation are a real concern for some of the alternative gases. For any suppression system, then, discharge of an agent due to a false-positive detection of a fire carries with it a severe penalty for the air carrier.

Once the fire suppression system has been activated, the flight is diverted to the nearest suitable airport. This may be up to three hours away, and could be in an area unfamiliar to the pilot or at an airport with minimal facilities causing potential for additional hazards to the aircraft and occupants. Unfamiliarity and lack of facilities provide added risk in addition to those resulting from an emergency evacuation. In the event of a real fire, the risks associated with this chain of events are obviously acceptable considering the alternative to not detecting the fire. But the consequences of a detector mistakenly classifying a nuisance signal as a fire threat are costly and dangerous.

The primary design goal for an aircraft cargo area fire detector is that it always respond positively to a real fire and always respond negatively to a non-threatening condition. Redundancy is used in the design of aircraft fire detection systems to reduce the chance that an alarm is due to a detector fault. Even so, false alarms occur at a rate far greater than the number of actual fires, with estimates of ratios ranging between 10:1 and 500:1. Interestingly, the one U.S. Air Force cargo aircraft that is protected with halon 1301 (the C5) has no reported incidents of false discharges. This is likely due to the accessibility of the cargo area in flight, which permits a crew member to investigate the area and to verify that the alarm is not false prior to the discharge of the halon. This is in contrast to commercial class C and D cargo spaces, where little is known about the state of the cargo environment during the range of normal operating conditions, and about how conditions are perturbed in the very early stages of a fire. Standard methods do not currently exist for evaluating the response

of detection systems to realistic early fire and nuisance stimuli, nor for evaluating detection systems that rely on new sensing technologies or combinations of sensors that have the potential for reducing the nuisance-signal-to-actual-fire ratio.

Discussion

The discussion sessions were focused on answering the following questions as they apply to aircraft cargo areas: (i) What conditions produced by a nascent fire can be sensed to warn of a threatening situation? (ii) In what time-frame must a response strategy be formulated, and what are the consequences of a false-positive? (iii) What physical environments or activities are likely to lead to a false-positive? (iv) What test methods are required to evaluate the immunity of fire detection systems to false-positives? (v) What are the action-items for the group, and who should take responsibility for each?

Smoke and particulate, temperature, major combustion gases (CO_2, CO, O_2, H_2O), relative humidity, minor gases (e.g., HCl), thermal radiation, and acoustic emission were mentioned as candidates to sense the presence of a fire. Combinations of smoke (ionization) plus CO and/or temperature, or smoke (photoelectric) and temperature were suggested as means to increase selectivity. A cargo area temperature readout in the cockpit was thought to be a good back-up indication.

The minimum time from the onset of a fire to its positive identification is stipulated in the FAR[7] to be one minute. The group felt, however, that the actual window to ensure safety depends upon the sensitivity of the detector and the event which triggers the fire. Tied into the equation is what additional information may be available to confirm the initial indication of a fire. The consequences of inappropriately classifying a non-fire state as a fire were identified to be needless diversion, emergency landings, possible evacuation injuries, reduced confidence in the system, and release of halon 1301 to the atmosphere.

The sources of false-positive indications depend upon the sensor. For smoke detectors, condensation was given as the leading nuisance. When on the ground, sand and dust, as well as particulate matter from engine exhausts, can lead to false alarms,. Gas detectors (primarily on the ground) are also susceptible to exhaust emissions (CO, CO_2) from auxiliary power units and taxiing aircraft. Livestock emit moisture, CO_2, CO, and CH_4. Fruits, vegetables and flowers emit water vapor and are often treated just prior to the closing of the cargo doors, producing condensation which can trigger a smoke or gas detector.

The success of a test method for background nuisance sources is tied to how well one is able to evaluate the response of the detector to a simulated fire. A considerable effort is required to make sure that the fire used to evaluate a detection system corresponds to a realistic threat, that the simulation is equally valid for a range of detection options (e.g., smoke, heat, gas), and that the fire simulation is repeatable. Once a standard fire is defined, such as those used by UL[2] or the European Community[12], then one needs to define the standard non-fire. A better understanding of the environment within the cargo area and a more thorough assessment of the historical causes of false alarms are needed before new test methods can be developed. From anecdotal evidence, moisture is a major source of false alarms; hence, a new test to evaluate the immunity of a detector to condensation is likely to be necessary. The application in class D spaces of detection systems designed for class C cargo areas sometimes requires installing the detector in a recessed pan. A method needs to be devised to account for the change in transport to the sensing element due to the recessed location. The operating software and system logic are an integral part of the fire detection system and need to be certified along with the sensor in a fire and non-fire state.

Actions are required by a number of groups to reduce the number of nuisance alarms from aircraft cargo area fire detection systems. The FAA, NASA, NIST, and UL can all play a positive

role, but the direct involvement of the airlines, airframers and fire protection equipment suppliers is required to ensure successful development and implementation of any new test methods or certification procedures. The key items to be addressed are the following: defining realistic fire threats and simulating them; documenting existing aircraft environments; simulating aircraft environments that lead to false alarms; determining requirements of the airline industry in regards to the tolerable rate of nuisance alarms; and examining current operating practices (e.g., the carrying of livestock, or spraying of flowers) as a means to identify opportunities to reduce false alarms.

RECOMMENDATIONS

Recommendations from the workshop are listed below under three categories: general in nature and applying to multiple commercial installations, specific to telecommunications, or specific to aircraft cargo areas. When it is obvious which organizations should take part in implementing the recommendations, they are so indicated.

General

- Assemble available data on the environmental conditions within aircraft cargo areas and critical telecommunication spaces. (users, equipment suppliers)

- Expand capabilities of the NIST FE/DE to simulate common environmental nuisance sources including dust, combustion engine exhaust gases, and relative humidity, and develop protocol to evaluate detection systems exposed to these environments. (NIST, certifying agencies, equipment suppliers, users)

- Develop industry consensus on what constitutes "acceptable" performance for new classes of detection systems. (users, equipment suppliers, certifying agencies)

- Investigate methods for evaluating and certifying proprietary software to ascertain its ability to discriminate a fire from a non-fire state in the presence of nuisance background sources. (certifying agencies, equipment suppliers, users, NIST)

- Develop safe, convenient, and scientifically sound techniques to certify detection systems as installed in the field. (certifying agencies, NIST, users, equipment suppliers)

- Demonstrate ability of computer models to predict the transport of aerosols from a source (fire, suppression action, or natural ventilation system) to the detector and other critical surfaces within a protected space. (NIST, FAA, NASA, NFPA, users, equipment suppliers)

Telecommunications Facilities

- Expand capabilities of NIST FE/DE to simulate nuisance sources found from soldering practices used on central office mainframes, and develop protocol to evaluate detection systems exposed to this environment. (telecommunications industry, NIST, detection equipment suppliers)

- Determine the impact of fire generated aerosols and suppression activities on materials and devices

critical to maintaining the dial tone. (telecommunications industry, NIST, agent manufacturers)

Aircraft Cargo Areas

- Compile background data from currently installed fire detectors to establish range of conditions (e.g., estimates of particle loading, temperatures) normally encountered in the non-fire state, identify the major sources of nuisance alarms, and develop instrumentation package to fill in critical data on the non-fire state of aircraft cargo areas, with emphasis on class D. (FAA, NASA, NIST, airlines, airframers, detection equipment suppliers)

- Produce an industry accepted accounting of cargo bay related fire incidents, false alarms, and associated actions and costs. (airlines, airframers, equipment suppliers, FAA)

- Expand capabilities of NIST FE/DE to evaluate the ability of current and emerging sensing technologies to discriminate fires from elevated nuisance background levels. Begin with test methods to simulate relative humidity up to the saturation point and temperatures from 4 °C to 50 °C (40 °F to 122 °F), making use of numerical computations as appropriate. (NIST, FAA, NASA, airframers, airlines)

- Develop aircraft certification methods and allowances for alternative detection methods (e.g., CO, radiation, and combination sensors).

- Develop consensus among the regulators, users, and fire researchers on realistic fire threats to be detected, as specified by fuels, geometry, rates of heat release, and times to detection. (FAA, NASA, NIST, airlines, airframers)

- Develop a methodology to simulate the consensus fires, and establish acceptable limits for run-to-run variation. This should be done in concert with the FAA's ongoing effort to develop standard fires for evaluating alternatives to halon 1301 suppression systems, and should build off the test fires already developed for ground-based applications by UL and the European Community, and the research conducted by NIST and detector manufacturers. Computational methods should be used to support the physical tests in the FAA facility. (FAA, NASA, NIST, airlines, airframers, detection equipment manufacturers)

- Develop and install a continuous temperature monitor for all inaccessible cargo areas to give the status to the pilot in the event of a fire alarm and subsequent suppression actions. The temperature reading alone should not be the basis of determining whether or not a fire is present, but should supplement the ability of the crew to respond to a fire alarm in more effective manner. (detection equipment manufacturers, FAA, airframers, Airline Pilots Association)

Appendix A

EVALUATING FIRE DETECTION SYSTEM RESPONSE TO NUISANCE SOURCES

Current fire sensing methods

Commercial fire detection systems are typically designed to sense temperature, airborne particulates, or electromagnetic radiation at prescribed locations in a room. Temperature sensors are based upon thermistors and thermocouples, or can be mechanical in nature (e.g. the fusible link in a sprinkler head). Airborne particulates can be sensed by the attenuation of light, the scattering of light, or the change in ionization from a radioactive source. Flame detectors, which are not normally used in aircraft cargo areas or telecommunication equipment, sense electromagnetic radiation in the infrared and/or ultraviolet spectrum. Comprehensive discussions of these and alternative fire sensing methods and their applications can be found in a number of review articles.[13, 14]

A single point detector is represented by the diagram in Fig. A1, independent of the sensing mechanism. The sensor responds to a physical stimulus in the environment and converts the response to an electrical current or voltage. The electrical signal is processed according to the manufacturer's algorithm and a decision is made to alarm or not. In the event of an alarm, people take action according to prearranged plans. Possible actions include confirmation of the fire through inspection or remote means, depowering electrical equipment, activation of fixed or manual suppression systems, evacuation, and informing the fire brigade. Depending upon the progress of the fire or the impact of the suppression process, the detection systems may continue to provide data useful to the structure operators and fire fighting team.

For protected areas which are inaccessible, or for suppression systems that are triggered automatically by the fire detector, the direct link between the room of origin and a person making the response decision does not exist. Users, equipment manufacturers, and regulators need to have ultimate confidence in a fire detection system that a real fire will never be missed under these conditions, yet the inaccurate classification of a non-fire state as a fire can lead to an inappropriate decision with costly and dangerous consequences. Test methods have been developed for evaluating a system's ability to detect standard fires or smoke-type aerosols. These are reviewed below. Standard methods do not exist for defining the non-fire state.

Standard Detector Test Fires

Underwriters Laboratories standard UL 217[2] describes how a smoke detector is certified to respond to a fire threat. Four different fuel sources are used to challenge the detector: newsprint, gasoline, wood and styrene. The European standard, CEN 54[12], specifies six different test fires to cover a broad range of conditions, including pyrolyzing wood, smoldering combustion and flaming combustion, with heat release rates(HRR) between 2 kW and 150 kW. These standard fires are listed in Table 1.
Measurements were made of the major products of combustion in a number of the above standard fires. Pfister[15] and Jackson and Robins[16] measured temperature, the response of a standard particle detector, water vapor, and some combustion gases near the ceiling of standard rooms with the EN 54 fires burning. Grosshandler et al.[17,18] measured fuel mass loss, CO_2, CO, H_2O individual and total hydrocarbons, particulate matter, temperature, and velocity in the plumes above the TF 1 and TF 2 fires. Figure 2 is an example of the repeatability obtained for the pyrolyzing wood fire, with the mass loss for five successive test shown as a function of time into the test. (Note that the test was considered over once flaming began.)

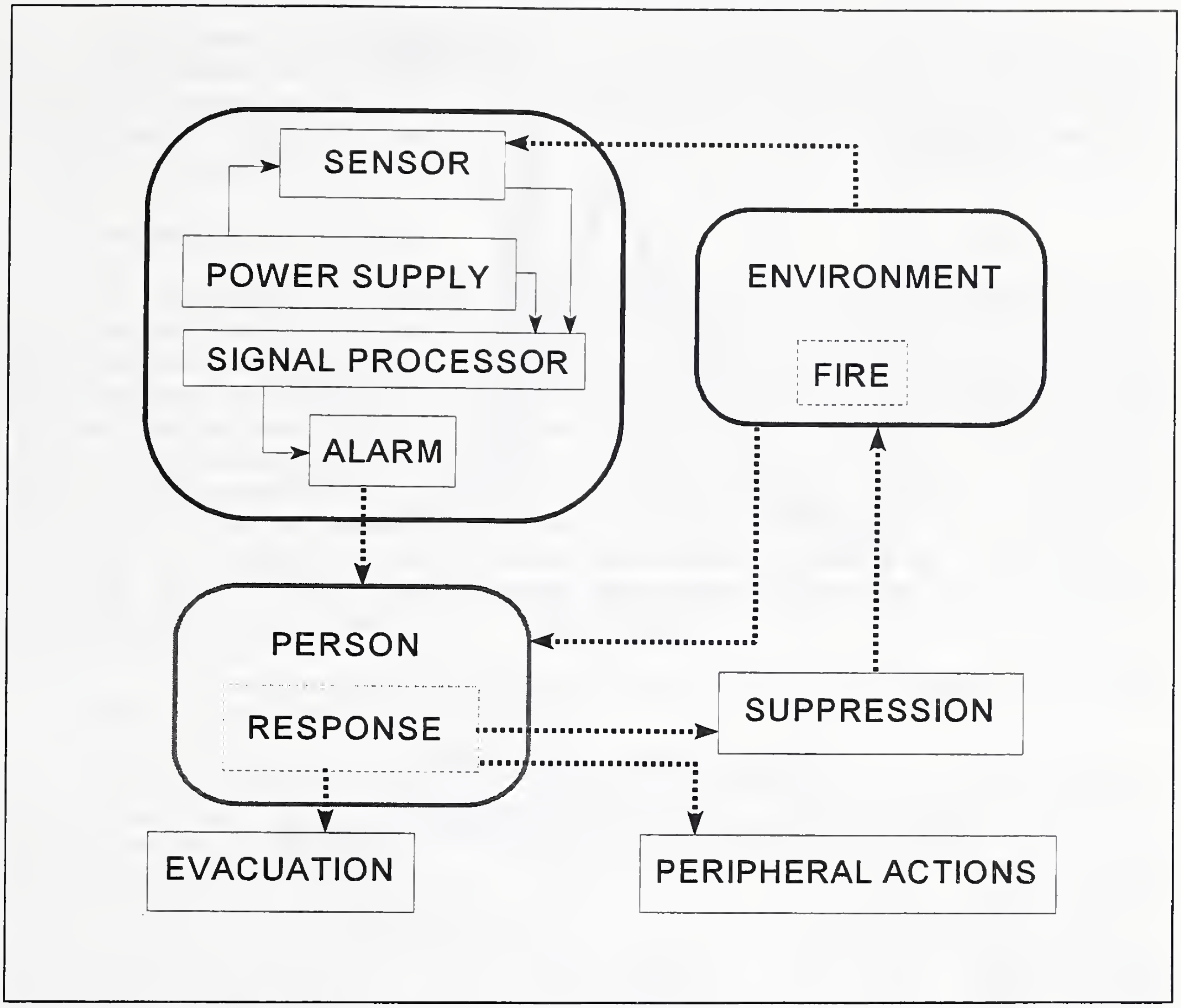


Figure A-1. Generic fire detector response block diagram

Table A-1. Standard fires in full-scale rooms.

DESIGNATION	FUEL	AVERAGE RHR
EN 54/TF 1	2800 g WOOD	56 kW (FLAMING)
EN 54/TF 2	130 g WOOD	2.3 kW (PYROLYZING)
EN 54/TF 3	270 g COTTON	3.2 kW (SMOLDERING)
EN 54/TF 4	300 g URETH.	30 kW (FLAMING)
EN 54/TF 5	650 g HEPTANE	150 kW (FLAMING)
EN 54/TF 6	2000 g ETHANOL	120 kW (FLAMING)
UL 217/A	43 g NEWSPRINT	3.2 kW (SMOLDERING)
UL 217/B	593 g WOOD	52 kW (FLAMING)
UL 217/C	25 g GASOLINE	6.2 kW (FLAMING)
UL 217/D	25 g STYRENE	5.1 kW (FLAMING)

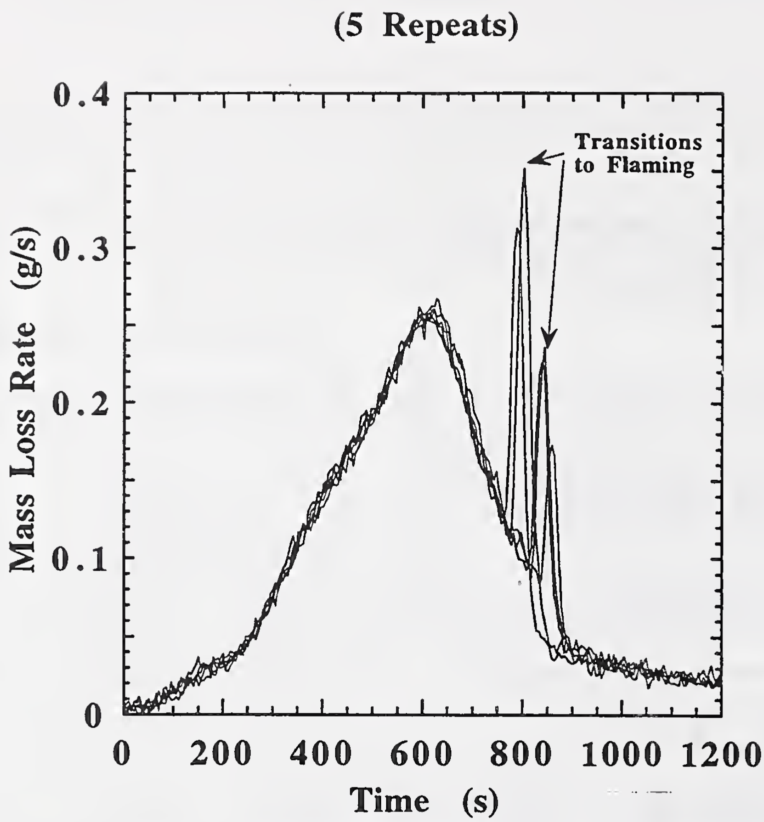


Figure A-2. Repeated mass loss traces for EN 54 pyrolyzing wood test fire (TF 2).

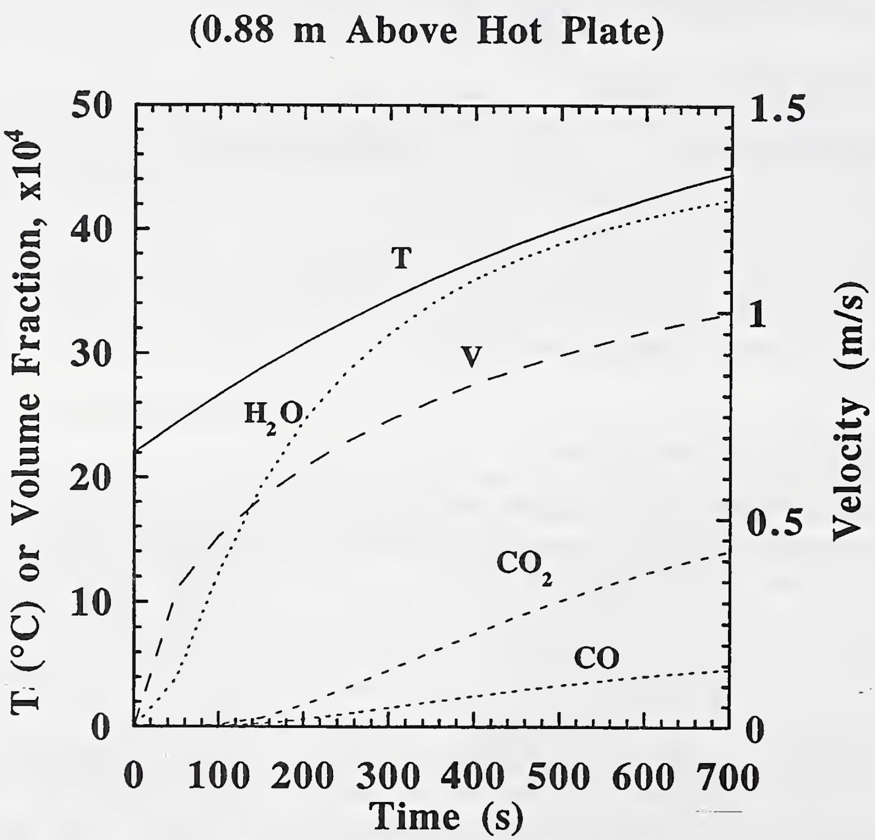


Figure A-3. Model curves for the plume velocity, temperature and concentration of major species 0.88 m above base of pyrolyzing wood test fire.

The objective of this study was to develop generic equations for the time-varying source of mass, species, momentum and energy that were produced in the lower portion of the test fire, and to use these source terms in models of the transport of heat and matter throughout the volume in which the fire was located. Figure A-3 shows how the experimental data were fit to simple exponential and polynomial curves for TF 2.

Defining the Non-fire State

The “non-fire state” exists whenever the “fire state” does not. Significant information can be gained from detectors during the well over 99.99 % of the time that the environment is in the non-fire state. This information may be buried in the amplitude, frequency and slope of the transient analog signal from the currently installed sensor. By installing multiple detectors at different locations in the room, additional information can be obtained about the non-fire state. Other information that would be useful in discriminating the two states could come from air pressure and velocity sensing; unburned fuel concentration measurements; O_2, H_2O, and CO_2 levels; CO, NO_x, HCl, HCHO, or other trace species levels; the size and make-up of particulates; knowledge of whether vents or doors are open; and whether or not people or animals are present. Whatever additional sensing is used to help identify the non-fire state, there is a need for a test method analogous to the standard detector test fires to evaluate the performance of the detection system under situations that will make up the bulk of its useful service life.

Role of Computational Fluid Dynamics

Even when standard test methods can be agreed upon to simulate fire (and non-fire) conditions, such tests are limited to specified room geometries and boundary conditions. Fire test facilities can be costly to maintain and inconvenient to run, and test-to-test variations are large because boundary and initial conditions are not tightly controlled. Computational Fluid Dynamic (CFD) codes and computer speeds have advanced to the point that meaningful numerical predictions now can be made for relatively complex and realistic scenarios[19,20]. Once the appropriate computational algorithm has been chosen and the basic griding of the room geometry established, "what-ifs" can be investigated easily with the code. For example, one could check the impact of moving a standard test fire from the center of the room to a corner, or see what happens if the detector is placed near a ceiling beam or close to the door soffit. If the ventilation flow is increased or decreased, it is possible to determine how this may effect the time that the effluent from the fire reaches the location of the detector, or whether a nuisance source external to the room is entrained at a level high enough to trigger the alarm.

Figure A-4 is a representation of a fire spreading across a bed in a generic hotel room[19], while Fig. A-5 shows how a smoke plume is diverted by a ceiling beam[20]. Similar types of calculations could be used to investigate smoke spread within an aircraft cargo area or between equipment bays of a telephone exchange.

Fire-Emulator/Detector-Evaluator

A spot detector responds only to its immediate environment, which is invariably remote from a burgeoning fire. Because the bulk of the chemical reaction and heat release occurs very close to the base of a fire, the major products of combustion are transported inertly by buoyant forces and background currents from just above the fire source to the detector location. A laboratory wind tunnel has been built at NIST to reproduce the environment that a detector would see if it were exposed to one of the UL 217A or EN 54 test fires[21]. Using the concentrations of gases, plume velocity, and

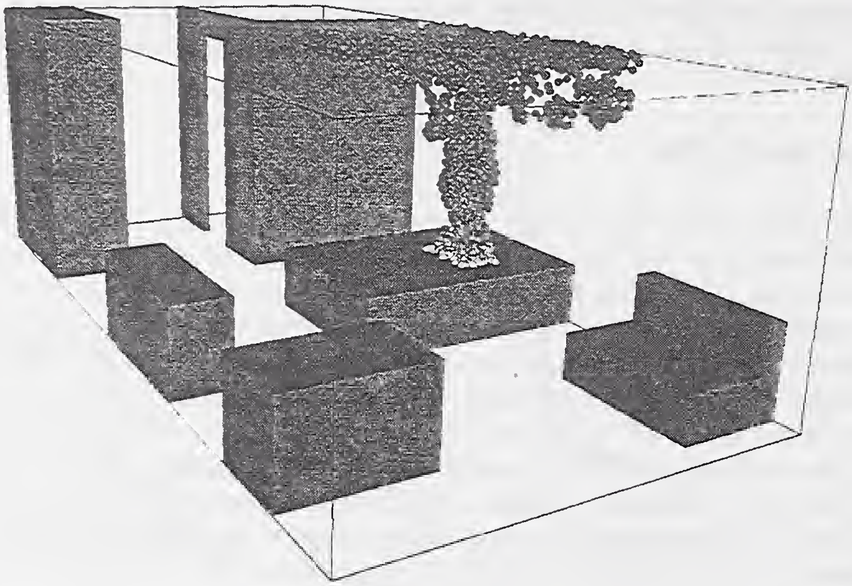
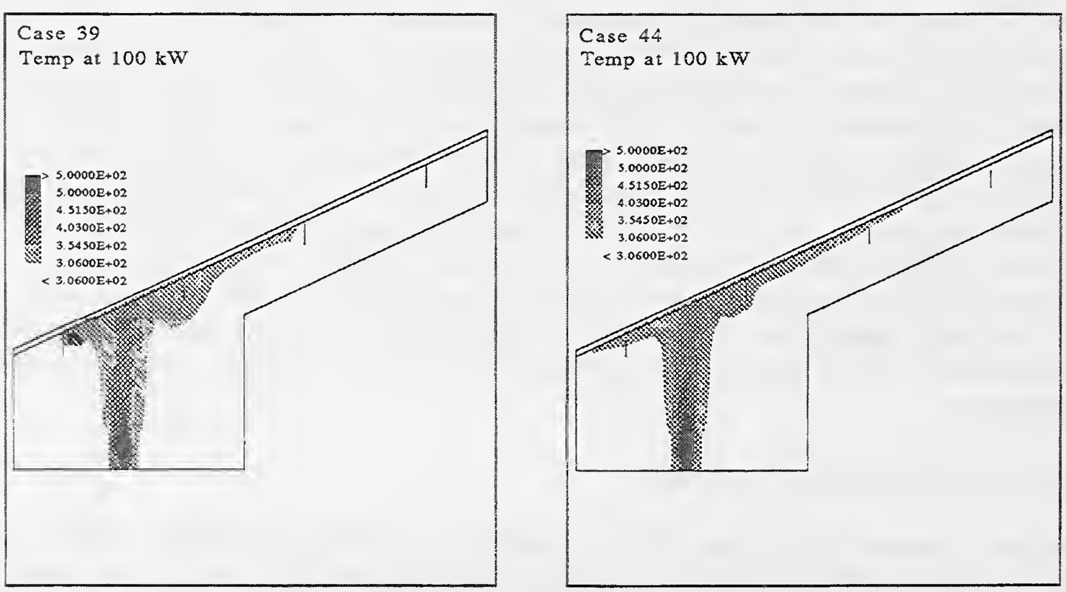


Figure A-4. LES model of a hotel room fire.



(a) 100 kW, no gap

(b) 100 kW, 0.13 m (5.0 in) gap

Figure A-5. CFD model of a fire plume interacting with a ceiling beam.[20]

temperatures measured in the standard fires and numerical models to predict the transport of products (refer to Fig. A-2), a blower, electrical heater, soot generator and gas mixer have been configured to emulate the conditions surrounding a spot detector over the entire period of the test fire. The advantages of artificially creating a "fire" in a wind tunnel are that the boundary and initial conditions of a test can be more precisely controlled, a full-scale room test facility does not need to be maintained, and the emulator can be automated to recreate a wide variety of situations for evaluating the detection system.

Figure A-6 is a block diagram of the major components of the fire-emulator/detector-evaluator (FE/DE). The detector test section is 0.3 m high and 0.6 m wide, within a straight section of sheet metal ducting which is 4 m long. The blower/heater combination can deliver air velocities up to 2.0 m/s and temperatures close to 90 °C. A small propene/air diffusion flame is used to generate smoke. The diagram shows that CO_2, can be proportioned into the air stream; provisions for other gases such as CO and methane are currently being added to the system. The temperature, flow rate, and species concentrations are set with the computer and measured at the location of the detector. Particle visualization using light scattering from a laser sheet is planed to observe the flow of smoke around the detector. Humidity control and refrigeration are being contemplated to better emulate the environment within an aircraft cargo area.

Table A-2 summarizes the range of conditions to be mimicked and types of detectors to be evaluated in the current generation FE/DE. Smoldering waves, either self-sustained or endothermic, and flaming fires of hydrocarbon-based fuels are being considered; detonations from explosive mixtures of gases or aerosols are not; the former indicated with a "Y" (yes) and the latter by an "N" (no). The detectors that could be accommodated are classified as single-element gas-type (current and future designs), single element particulate such as the current generation of photo and ionization detectors, single element temperature or heat flux, and any combination of these. A limited type of line or beam detector could also be evaluated, but detectors that view a wide angle (e.g., most radiation and flame detectors) would be incompatible with the FE/DE.

In addition to reproducing the fire, the emulator can also be used to create nuisance environments likely to be confused by the detector as a fire state. Table A-3 is a summary of the kinds of nuisance signals that can and cannot be produced in the FE/DE. The nuisances are grouped as exhaust products (e.g., from an aircraft APU or from a truck parked outside a building air intake), natural aerosols from humidity or dust, and consumer or industrial products such as cleaning sprays or the smoke from a soldering process. Electromagnetic radiation nuisance sources from, for example, the sun (UV), electronic equipment (RF), or external radioactivity can be significant sources of inappropriate alarms, but are not emulated in the facility. Some detectors are naturally immune to certain interference (e.g., a CO sensor will not respond to dust particles and a smoke detector is unlikely to be fooled by modest changes in environmental temperature); hence, the corresponding entry in the table is "N".

Concluding Remarks

A facility such as the FE/DE can be used to advantage by fire detection equipment manufactures, users and certifying agencies to develop more intelligent algorithms and new sensing strategies capable of distinguishing a true fire condition from a nuisance environmental disturbance. By working collaboratively with the impacted industries, testing laboratories, and other governmental agencies, fire detection systems can become available that will reduce substantially the number of misleading alarms while maintaining the high degree of sensitivity and selectivity required by the telecommunications and aircraft industries.

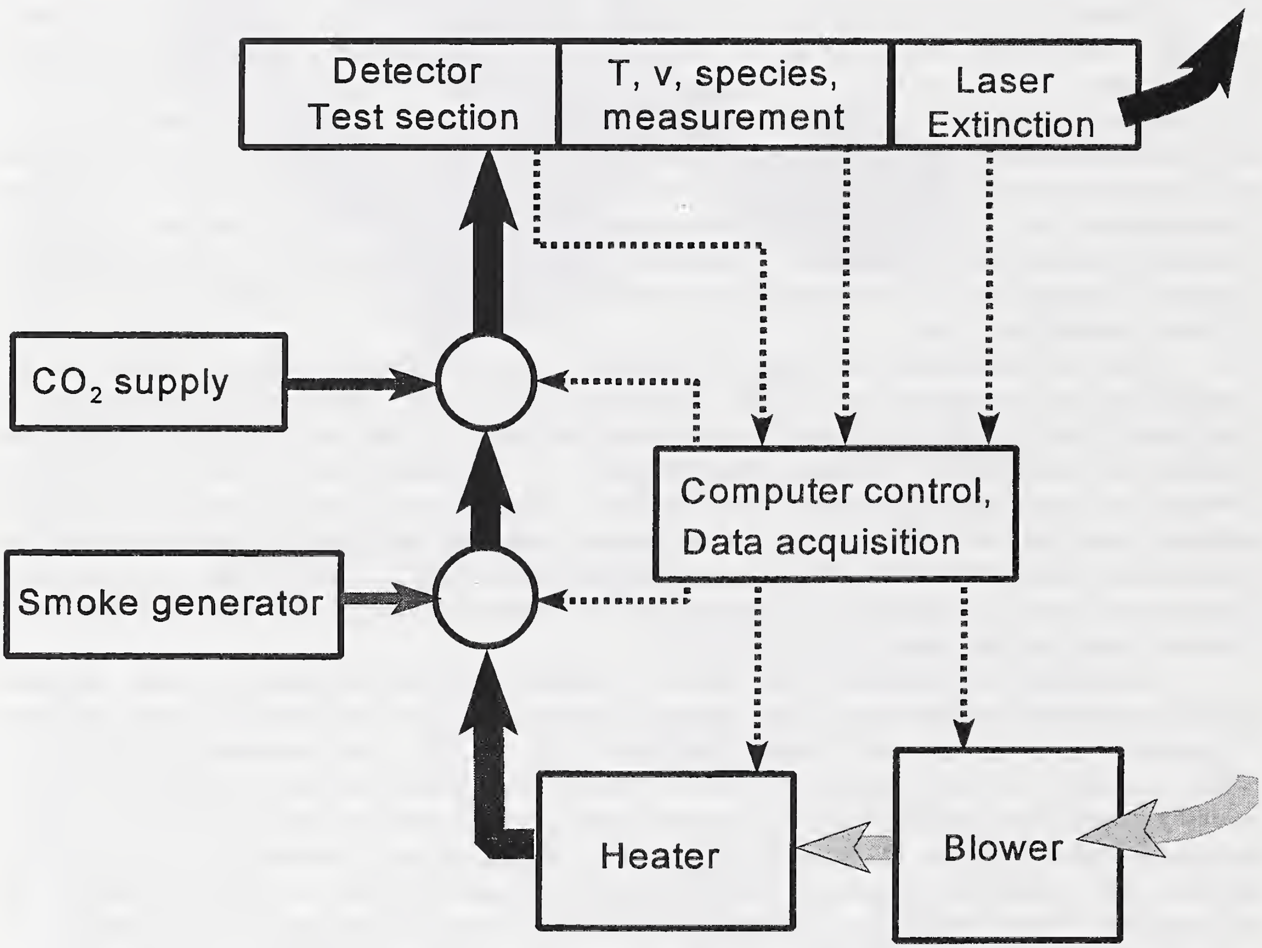


Figure A-6. Block diagram of the Fire-Emulator/Detector-Evaluator (FE/DE)

Table A-2. FE/DE spot detector applications matrix.

PARAMETER DETECTED	SMOLDER WAVE		DEFLAGRATION			DETONATION	
	HEAT SOURCE	SELF-SUST.	GAS FUEL	LIQ. FUEL	SOL. FUEL	GAS	AERO-SOL
SINGLE-ELEMENT, GAS:							
CO, CO_2, H_2O, O_2	Y	Y	Y	Y	Y	N	N
NO_x, HCs, CH_4, H_2	Y	Y	Y	Y	Y	N	N
HCl, HF, HCN, SO_x	Y	Y	Y	Y	Y	N	N
SINGLE-ELEM., PARTICULATE:							
SMOKE < 100 nm	Y	Y	Y	Y	Y	N	N
SMOKE > 100 nm	Y	Y	Y	Y	Y	N	N
FUEL AEROSOLS	Y	N	N	N	N	N	N
SINGLE-ELEM., THERMAL:							
TEMPERATURE	Y	Y	Y	Y	Y	N	N
HEAT FLUX	Y	Y	Y	Y	Y	N	N
MULTI-ELEM. COMBINATIONS	Y	Y	Y	Y	Y	N	N

Table A-3. FE/DE nuisance applications matrix for spot detectors

DETECTOR EVALUATED	ENGINE EXHAUST, COOKING			NATURAL AEROSOLS		CONSUMER PRODUCTS		E & M RAD.	
	GAS	PART.	HEAT	DUST	H_2O	GAS	PART.	RF, X, γ- RAY	UV, IR VIS
GAS	Y	N	N	N	N	Y	N	N	N
PARTICULATE	N	Y	N	Y	Y	N	N	N	N
THERMAL	N	N	Y	N	N	N	N	N	N
COMBINATION	Y	Y	Y	Y	Y	Y	Y	N	N

Appendix B: Agenda

FIRE DETECTOR WORKSHOP III

December 4-5, 1997
Building and Fire Research Laboratory
National Institute of Standards and Technology
Gaithersburg, MD 20899

Thursday, December 4

Administration Building, Lecture Room A

8:30	Registration
9:00	Welcome, Jack Snell, Deputy Director BFRL, NIST
9:10	Introduction to the Workshop, William Grosshandler, Leader, Fire Sensing and Extinguishment Group, NIST
9:15-10:45	False Alarms in Aircraft Cargo Area Fire Detection Systems John O'Sullivan, British Airways Scott Hammann, Boeing - Phantom Works Matt Kolleck, Booz-Allen & Hamilton David Blake, Federal Aviation Administration Technical Center
10:45	Break
11:00-12:30	Fire Detection in Critical Telecommunications Installations Ron Marts, Bellcore Miles Hanley, Bell Atlantic Jeffrey Betz, AT&T John Parssinen, Underwriters Laboratories
12:30	Lunch
1:30	William Grosshandler, Evaluating Fire Detection System Response to Nuisance Sources
2:00-3:30	Breakout Sessions Aircraft Session A - Admin CR-B111 (Thomas Cleary, NIST) Aircraft Session B - Bldg. 224, room B245 (David Blake, FAA) Telecommunication Session A - Admin CR-B113 (Emil Braun, NIST) Telecommunication Session B - Bldg. 226, room B224 (Richard Bukowski, NIST)
3:30	Break
3:45-5:00	Continue Breakout Discussions

Friday, December 5

8:00-9:00	Wrap-up Breakout Discussions (same room assignments)

Administration Building, Lecture Room A

9:00-9:20	Report from Aircraft Session A (Thomas Cleary, NIST)
9:20-9:40	Report from Aircraft Session B (David Blake, FAA)
9:40-10:30	Open discussion to build consensus on aircraft cargo area nuisance sources
10:30-10:45	Break
10:45-11:05	Report from Telcom Session A (Emil Braun, NIST)
11:05-11:25	Report from Telcom Session B (Richard Bukowski, NIST)
11:25-12:15	Open discussion to build consensus on telcom nuisance sources
12:15-12:30	Future actions
12:30	Close of workshop

Appendix C

BREAKOUT SESSIONS

Aviation

A. Thomas Cleary, NIST
(Admin CR-B111)

Tony Dybicz, UTRS
James Gourley, Nat'l Railroad Passenger Corp.
Scott Hammann, Boeing - Phantom Works
Gary Hunter, NASA-Lewis
Richard Lukso, Securaplane
Vahid Motevalli, George Washington Univ.
John O'Sullivan, British Airways
Yudaya Sivathanu, Purdue Univ.
Ron Sparks, Walter Kidde Aerospace

B. Dave Blake, FAA Tech. Center
(Bldg. 224, room B245)

Matt Kolleck, Booz-Allen & Hamilton
Irv Ellner, Cerberus Pyrotronics
Robert Frantz, Airline Pilots Assoc.
Lawrence Langley, Vatell Corp.
James Milke, Univ. of Maryland
Brian Morris, Firelite/Notifier
Ed Niple, Aerodyne
Joe Oullette, Simplex Time Recorder
Glynn Rountree, Aerospace Ind. Assoc.
David Urban, NASA-Lewis

Telecommunications

A. Emil Braun, NIST
(Admin CR-B111)

Jeffrey Betz, AT&T
Barry Cronk, Allendale Insurance
Artur Chernovsky, NIST
Jerry Gordon, GTE Wireless
Dan Gottuk, Hughes Assoc., Inc.
Ron Kirby, Simplex Time Recorder
Ron Marts, Bellcore
John Parssinen, Underwriters Laboratories
Mark Robin, Great Lakes Chem.
Lev Sadovnik, Waveband
Ralph E. Transue, The RJA Group
Samuel Wen, ADT
Henry Whitesel, US Navy

B. Richard Bukowski, NIST
(Bldg. 226, room 224)

Don Bales, DJS Assoc.
Jesse Denton, Zurich American
Miles Hanley, Bell Atlantic
Walter Jones, NIST
Larry Maruskin, US Fire Administration
Larry McKenna, Hughes Associates
Jim Qualey III, Simplex Time Recorder
Scott Vandame, Schrimer Engineering
Jim Wiemeyer, Pittway Systems Tech.
Bernard Worst, ADT
James R. York, Cerberus Pyrotronics

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Appendix E: REFERENCES

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The need for faster and more intelligent decision making regarding the presence or absence of a fire threat has become acute in the commercial aircraft and telecommunications industries, both of which have been particularly hard-hit by the cessation of halon production. The drive toward earlier detection has as a consequence the possibility of increased rate of nuisance alarms; however, there are no accepted standards against which a fire detection system can be operated to assess its immunity to false alarm. A workshop was held at NIST with the main objective to identify physical sources of nuisance alarms that may plague current and emerging fire detection technologies for telecommunications applications and for aircraft cargo areas, to reach consensus on what test methods are appropriate to evaluate a detection system's immunity to false alarm in the presence of physical nuisance sources, and to recommend actions to develop and/or implement these new test methods. The workshop consisted of a number of invited background talks from representatives of the aircraft and telecommunications industries and government agencies. Among the topics discussed were defining realistic fire threats and simulating them; documenting existing environments; simulating environments that lead to false alarms; determining requirements of the industry with regard to the tolerable rate of nuisance alarms; and examining current operating practices as a means to identify opportunities to reduce false alarms.

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